SEMESTER III

20SA31 APPLIED GRAPH THEORY

3 0 0 3

Prerequisites:
20SA15 – Discrete Mathematics.

Basic Concepts: Graphs, digraphs, subgraphs, graph models, graph representations, degree sequence. Walk, trail, path, connected graph, distance, diameter, clique, independent set, vertex cover. Graph isomorphism, graph decomposition. Algorithms – time and space complexities. Depth-first and breadth-first search algorithms. (10)

Trees & Connectivity: Trees – characterizations, spanning tree - matrix tree theorem, Prim's and Kruskal's algorithms, Cayley's formula. Shortest path problem – Dijkstra's algorithm, Floyd's algorithm for all pair shortest path. Vertex and edge connectivity, relationship between vertex and edge connectivity, bounds for connectivity. Constructing reliable network- Harary's k-connected graphs. (10)

EULERIAN & HAMILTONIAN GRAPHS: Eulerian trails and tours. Optimal Chinese Postman Tour – Edmond's and Johnson algorithm, Eulerian trail – Fleury's algorithm, Hierholzer's Algorithm. Hamiltonian cycles – Ore's and Dirac's conditions. Gray codes, Traveling Salesman problem – Christofide's algorithm. Walecki's construction. . (8)

MATCHING &NETWORK FLOWS: Matching, Bipartite matching, Hall's theorem, Perfect matching, Tutte's 1-factor theorem, augmenting path algorithm, Edmonds's Blossom Algorithm, Gale–Shapley algorithm. Flows and cuts, maximum flow problem, Max-flow Min-cut Theorem, Ford-Fulkerson Algorithm. (9)

COLORING & PLANAR GRAPHS: Vertex-coloring – upper chromatic number, bounds using clique number, maximum degree, Welsh – Powell theorem. Sequential and largest degree first algorithms, applications to frequency assignment. Euler's formula, dual graph, Kuratowski's theorem, 4-color problem, Wagner's theorem. Planarity testing – Hopcraft-Tarjan algorithm (8)

Total L : 45

TEXT BOOKS:
1. Jonathan Gross and Jay Yellen, 'Graph Theory and its Applications', CRC Press, Boca Raton, 2019.
2. Bondy J.A. and Murty U.S.R., 'Graph Theory' Springer, 2013.

REFERENCES:
1. Douglas B West, 'Introduction to Graph Theory', Pearson, 2018.
2. Balakrishnan R and Ranganathan K, 'A Textbook of Graph Theory', Springer, 2012.
3. Thulasiraman K and Swamy M N S, 'Graphs: Theory and Algorithms', John Wiley, 2014.
4. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, 'Introduction to Algorithms', MIT Press, 2009.

20SA32 OPTIMIZATION TECHNIQUES

3 0 0 3

Prerequisites:
20SA15 – Contemporary Algebra.

LINEAR PROGRAMMING: Linear programming modeling – Solution techniques – Graphical method, Simplex method, Big M method , Two Phase method - Special cases of Simplex method. (10)

DUALITY AND SENSITIVITY ANALYSIS: Sensitivity Analysis for Graphical method and general linear programming model- Dual Problem – Primal and Dual relationship – Economic Interpretation of duality – Dual Simplex method – Post Optimal Analysis (9)

NON-LINEAR PROGRAMMING: Elimination methods for one dimensional minimization problems – Unimodal function - Interval halving method, Fibonacci method, – Hooke and Jeeves pattern search method – Indirect search methods – Cauchy's steepest descent method, Fletcher-Reeves conjugate gradient method . (8)

DECISION MAKING: Decision making under certainty and uncertainty – decision making under risk (6)

DYNAMIC PROGRAMMING : Principle of optimality **-** Forward and Backward Recursion methods – Shortest route problem - Knapsack model – Work force size model (6)

FINANCIAL APPLICATIONS : Dynamic Programming approaches to solve Financial problems - Option Pricing using Binomial Lattice - Mortgage backed securities (6)

Total L : 45

TEXT BOOKS:
1. Hamdy A Taha, 'Operations Research :An Introduction', Pearson Education, 2017
2. Singiresu S Rao, 'Engineering Optimization Theory and Practice', John Wiley, 2014.

REFERENCES:
1. Hillier.F and Lieberman G J,'Introduction to Operations Research', Tata Mc-Graw Hill, 2012.
2. Cornuejols and RehaTutuncu, 'Optimization Methods in Finance', Cambridge University Press, 2007.

20SA33 NUMBER THEORY AND CRYPTOGRAPHY

3 0 0 3

Prerequisites:
20SA15 – Contemporary Algebra.

ARITHMETICAL FUNCTIONS: Divisibility-Division Algorithm, Euclidean Algorithm; Primes-Fundamental Theorem of Arithmetic: Arithmetic function-Euler totient function. (6)

CONGRUENCES: Introduction to Congruence - Definition, properties, Ring of integer modulo n, Prime field, Primitive roots, Irreducible polynomial, Chinese remainder Theorem, Euler, and Fermat Theorem, Legendre, Jacobi, and Quadratic Reciprocity. (6)

CRYPTOGRAPHIC PRIMITIVES: Definitions and Illustrations: Symmetric-Key Cryptography, Classical Ciphers, Stream Ciphers, Block Ciphers LFSRs, Modes of Operation, DES, AES - Attacks. (9)

PUBLIC-KEY CRYPTOGRAPHY: Principles of PKC, RSA Cryptosystem, PKC based on the Discrete Logarithm problem -ElGamal Cryptosystem and Elliptic Curve systems. (9)

HASH FUNCTIONS AND SIGNATURE SCHEMES: Hash functions based on Cryptosystems, Message Digest, The RSA signature scheme, The Digital Signature Algorithm. The ElGamal signature scheme. (8)

KEY DISTRIBUTION AND KEY AGREEMENT: Introduction, Key transport based on symmetric encryption - Kerberos. Key agreement based on symmetric techniques - Blom's Scheme, Key transport based on public key encryption-Needham –Schroeder protocol, Key agreement based on asymmetric techniques- Diffie-Hellman key agreement protocol, station- to- station protocol. (7)

Total L : 45

TEXT BOOKS:
1. Neal Koblitz, 'A course in Number Theory and Cryptography', Springer, 2012.
2. Richard A. Mollin, 'Introduction to Cryptography', Chapman & Hall CRC, 2007.
3. Douglas R Stinson, 'Cryptography Theory and Practice', CRC Press, 2006.

REFERENCES:
1. Alfred J, Menezes, Paul C, Van Oorschot and Scott A Vanstone, 'Hand Book of Applied Cryptography', CRC Press, 2010.
2. Josef Pieprzyk, Thomas Harjono and Jenifer Seberry, 'Fundamentals of Computer Security', Springer, 2010.
3. Behrouz. A. Forouzan, 'Introduction to Cryptography and Network Security', Tata Mc-Graw Hill, 2010.
4 .Gustavus J. Simmons, 'Contemporary Cryptology', Wiley-IEEE Press, 1999.

20SA34 MACHINE LEARNING

3 2 0 4

Prerequisites:
20SA15 – Contemporary Algebra.
20SA14 - Probability, Stochastic Processes and Statistics

INTRODUCTION: Machine learning – Types – Supervised learning, unsupervised, Reinforcement learning, semi supervised learning (2)

SUPERVISED LEARNING: Regression – Linear – Polynomial – Multiple regression – Evaluation measures – Bias –variance –over fitting – under fitting – Regularization (8)

CLASSIFICATION: Linear classification – Logistic regression – linear discriminant analysis – Optimization – Convex set - Convex functions – Convexity checking - Loss functions for classification and regression - Gradient descent – variants – Perceptron - Support Vector Machines – Linear, Soft margin, Linearly non separable data - Kernel functions. (10)

NEURAL NETWORKS:: Multilayer perceptron - Back propagation – Training – Bayesian Classifier – Decision theory – Maximum A Posteriori estimate – maximum likelihood estimate K nearest neighbour classifier. (10)

DECISION TREES: Introduction – Purity measures – Entropy, cross entropy, information gain, gain ratio, Gini Index – Regression trees – ID3 – Pruning – Model selection – Bootstrapping and cross validation – Model evaluation – Performance Measures – Receiver operating characteristic curve (ROC) – AUC. (8)

UNSUPERVISED LEARNING: Clustering –Types - K-means – EM - Mixture of Gaussians –Spectral clustering - Cluster validity measures – dimensionality reduction- extraction – PCA (Principal components analysis) - ICA (Independent components analysis) - Applications : image segmentation – Image compression –Outlier analysis. (7)

Total L : 45 + T: 30 = 75

Tutorial Practices:

1. Download the datasets from UCI machine learning repository / www.kaggle.com for classification and clustering.
    a. Mail spam
    b. Breast cancer data
    c. Iris data
    d. MNIST dataset

2. Implement the following Classification algorithms on the above suitable datasets.
    a. Naïve Bayes
    b. LDA / QDA
    c. SVM
    d. K nearest neighbour
    e. Multi layer Perception
3. Do tenfold cross validation experiments and statistical validation using t-test and ANOVA.
4. Apply clustering for image segmentation and image compression.
5. Apply Spectral clustering on data sets and visualization through plots
6. Apply PCA / LDA / Factor analysis on Iris data set, reduce the dimension and visualize the data .
7. Apply semi supervised learning techniques on data sets for the following tasks: to fill missing values / classification

TEXT BOOKS:

1. David Barber, 'Machine Learning: A Probabilistic Approach', http://www.idiap.ch/~barber, 2006.
2. AlpaydinEthem, 'Introduction to Machine Learning', Massachusetts Institute of Technology Press, 2020.

REFERENCES:

1. Trevor Hastie, Robert Tibshirani and Jerome Friedman, 'The Elements of Statistical Learning', Springer, 2013.
2. Christopher M Bishop, 'Pattern Recognition and Machine Learning', Springer, 2016.
3. Richard O Duda, Peter E Hart and David G Stork, 'Pattern Classification (Digitized)', John Wiley, 2016.

20SA37 SCIENTIFIC COMPUTING LAB

0 0 2 1

Prerequisites:

20SA11 Contemporary Algebra
20SA13 Differential Equations

1. Solution of algebraic and transcendental equations- Newton Raphson method, method of false position, Graeffe's root squaring Method.

2. Solving linear system of equations by direct method and iterative method- Gauss elimination method, Crout's method , Gauss- Seidel method.

3. Computing Eigenvalue and Eigenvectors.

4.Interpolation with unequal intervals and equal intervals.

5.Numerical Differentiation and Integration

6.Taylor's series method, Euler's method, Modified Euler's method Fourth order RungeKutta method for solving first order differential equations'

7. Numerical solutions of Solution of one dimensional heat equation by explicit and implicit methods – One

dimensional wave equation and two dimensional Laplace and Poisson equation'

8. Solving LPP using simplex method and two phase method.'

TOTAL P: 30

TEXT BOOKS:
1. Steven C. Chapra and Raymond P. Canale, 'Nmerical Methods for Engineers with Software and Programming Applications', Mc-Graw Hill, 2011.

REFERENCES:
1. CurtisF. Gerald,andPatrickO. Wheatley, 'Applied Numerical Analysis', Pearson, 2011.
2. YousefSaad. 'Numerical methods for large eigenvalue problems', University Press, 2011.

20SA38 MINI PROJECT & SEMINAR

0 0 4 2

Mini – project is to be done during the summer vacation at the end of the second semester and a seminar is to be conducted during the third semester.

SEMESTER - IV

20SA40 PROJECT WORK

0 0 24 12

Every student shall undertake a project work during the fourth semester. The project work shall be undertaken in an industrial / research organization or in the college in consultation with the faculty guide and the Head of the Department. In case of the project work at industrial / research organization, the same shall be jointly supervised by a faculty guide and an expert from the organization.

PROFESSIONAL ELECTIVES

20SA61 ALGEBRAIC TOPOLOGY

3 2 0 4

Prerequisites:
20SA11 - Contemporary Algebra,
20SA12 - Real Analysis,
20SA21 - Topology and Functional Analysis.

ALGEBRAIC TOPOLOGY: Homotopy of Paths- The Fundamental Groups- Circle , group of S^n, Covering spaces- Retractions of fixed points- The fundamental theorem of Algebra. (9 + 6)

SEPARATION THEOREMS IN PLANE: The Jordan Separation Theorem—Invariance of domain-Jordan Curve Theorem- Imbedding graphs in a plane- Winding number of simple closed curve (10 + 7)

CLASSIFICATION OF SURFACES: Fundamental Groups of Surfaces-Homology of Surfaces- Cutting and pasting- The classification theorem- Constructing compact surfaces. (10 + 7)

AXIOMATIC APPROACH TO DIGITAL TOPOLOGY: Axioms of Digital Topology, Relation between the suggested and classical Axioms, Deducing the properties of ALF spaces from the axioms**.** (8 + 5)

ABSTRACT CELL COMPLEXES: Topology of complexes, Cartesian complexes and combinatorial coordinates, AC complexes compared with other Locally Finite Spaces (8 + 5)

Total L : 45 + T: 30 = 75

TEXT BOOKS:
1. James R. Munkres, 'Topology- A First Course', Pearson, 2018.
2. Allen Hatcher, 'Algebraic Topology', Cambridge University Press, 2002.

REFERENCES:
1. Herbert Edlesbrunner and John Harer, 'Computational Topology– An Introduction', AMS, 2010.
2. Vladimir A. Kovalevsky, 'Geometry of Locally Finite Spaces: Computer Agreeable Topology and Algorithms for Computer Imaginary', House Dr. BaerbelKovalevski, 2008.

20SA62 ARTIFICIAL INTELLIGENCE

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics,
20SA24 - Data structures

INTRODUCTION: The foundations of AI - The History of AI - Intelligent agents - Agent based system. (2)

PROBLEM SOLVING: State Space models - Searching for solution - Uninformed/Blind search - Informed/ Heuristic search - A* search - Hill-climbing search - Meta Heuristic: Genetic Algorithm - Adversary based search : Minimax – Expectimax – Alpha Beta pruning – Constraint satisfaction problem - Backtracking search. (10)

KNOWLEDGE REPRESENTATION AND REASONING: Knowledge representation - Logics - bivalent logic - inference - Fuzzy logic: membership - Fuzzy rules and reasoning - Fuzzy inference. (8)

UNCERTAIN KNOWLEDGE AND PROBABILISTIC REASONING: Uncertainty - Probabilistic reasoning - Semantics of Bayesian network - Exact inference in Bayesian network- Approximate inference in Bayesian network - Probabilistic reasoning over time – Inference in temporal models - Hidden Markov Models – Dynamic Bayesian Networks. (10)

DECISION-MAKING: Basics of utility theory, Utility functions - Sequential decision problems - Markov decision process - Value iteration - Policy iteration - Decisions in Multi agent system: Multi agent decision theory - Group decision making. (10)

LEARNING: Learning from observation – Supervised Learning: Neural networks - Unsupervised - Reinforcement learning. Robotics - Introduction. (5)

Total L : 45 + T: 30 =75

Tutorial Practices:
1. Implementation of blind search algorithms.
2. Implementation of Heuristic search algorithms like A* and Hill Climbing.
3. Solving 8 –puzzle and Missionaries and Cannibals problem.
4. Constraint satisfaction techniques
5. Logic based exercises.
6. Implementation of supervised and unsupervised learning algorithms.
7. Simple games – minimax and expectimax

TEXT BOOKS:
1. Stuart Russell and Peter Norvig, ‘Artificial Intelligence: A Modern Approach’, Pearson Education, 2020.
2. David Pool and Alan Mackworth, ‘Atificial Intelligence: Foundations of Computational agents’, Cambridge University Press, 2017.

REFERENCES:
1. Timothy Ross, ‘Fuzzy Logic with Engineering Applications’, John Wiley, 2016.
2. Tsang and Edward, ‘Foundations of Constraint Satisfaction: The Classic Text’, Academic Press, 2014.
3. Christopher M.Bishop, ‘Pattern Recognition and Machine Learning’, Springer, 2016.
4. Nils J. Nilsson, ‘The Quest for Artificial Intelligence: A History of Ideas and achievements’, Cambridge University Press, 2010.

20SA63 BIG DATA AND MODERN DATABASE SYSTEMS

3 2 0 4

Prerequisites:
20SA24 - Data structures,
20SA25 - Database Management System.

OBJECT AND SPATIAL DATABASES: Object Oriented Databases - Complex data types - Structured types and Inheritance – Query Processing in Object databases - Spatial Databases : Geometric Information System – Spatial Data Types – Spatial Queries - Spatial indexing techniques. (6)

PARALLEL AND DISTRIBUTED DATABASES: Architecture of parallel databases – Parallel query evaluation, Parallel Queryoptimization – Distributed DBMS Architecture, Distributed Database Design, Distributed Query Processing.. (5)

DATA MODELING FOR BIG DATA: Big Data and Challenges, Big Data models, NoSQL data models, Basic principles of NoSQL models, BASE properties, CAP Theorem, SQL databases VsNoSQL databases - MAP-REDUCE: Apache Hadoop andHDFS, SPARK. (10)

NOSQL DATABASES (PART 1): Key - Value Stores: Amazon DynamoDB, Key -Value Stores (in-memory) : Redis ColumnOriented Store: Google BigTable , Apache Cassandra - Hbase (10)

NOSQL DATABASES (PART 2): Document Oriented Stores – MongoDB - Apache CouchDB - Graph databases: Neo4J –Orient DB. (9)

DATABASE INTEGRATION: Data warehousing, Virtual Data Integration - Schema directed data integration - Schema mapping and information preservation (5)

Total L : 45 + T: 30 = 75

Tutorial Practices:
1. Creating and querying object relational data base
2. Implementing of spatial database and spatial data queries.
3. Distribution using Map- Reduce onBig Data (Hadoop)
4. Data Integration from heterogeneous Databases.
5. Implementation of No-SQL databases : DynamoDB, MongoDB, HBASE, Neo4J.

TEXT BOOKS:

1. Pramod J. Sadalage and Martin Fowler, 'NoSQL Distilled - Brief Guide to the Emerging World of Polyglot Persistence', Pearson Education, 2013.
2. Guy Harrison, 'Next generation Databases: NoSQL and Big Data', Apress, 2015.
3. Kristina Chodorow, Mongon DB 'The Definitive Guide', O'Reilly Media, 2019.
4. Holden Karau, Andy Konwinski, Patrick Wendell, MateiZaharia, 'Learning Spark: Lightning - Fast Big Data Analysis', O'Reilly Media, 2015.

REFERENCES:

1. RamezElmasri and ShamkranthNavathe , 'Fundamentals of Database Systems', Addison Wesley, 2016.
2. M.TamerOzsu, Patrick Valduriez, 'Principles of Distributed Database Systems', Springer, 2020.
3. Anhai Doan, Alon Halevy, Zachary Ives, 'Principles of data integration', Morgan Kaufmann, 2012.

20SA64 CALCULUS OF VARIATIONS AND TRANSFORMS

3 2 0 4

Prerequisites::
20SA12 - Real Analysis,
20SA13 - Differential Equations.

INTEGRAL EQUATIONS: Introduction - Linear integral equation of the first and second kind of Fredholm and Volterra type - Solutions with separable kernels – Eigenvalues – Eigenfunctions - Resolvent kernel – Construction of Green's function for BVP. (9 + 6)

CALCULUS OFVARIATIONS: Functional - Variation of a functional - Euler-Lagrange equation - Necessary and sufficient conditions for extrema - Variational methods for boundary value problems in ordinary and partial differential equations. (8 + 5)

LAPLACE TRANSFORM: Definition - Transforms of Standard Functions - Transform of unit step and Dirac delta functions – Transforms of derivatives and integrals –Derivative and integrals of Transforms- Transforms of Periodic functions - Inverse Laplace transform- Convolution Theorem. Solving ordinary linear differential equations with constant coefficient and solving integral equations using Laplace transform. (10 + 7)

FOURIER TRANSFORM : Fourier integrals - Fourier transform- Fourier sine and cosine transform - Transforms of standard functions - Properties, Convolution theorem (Statement only) – Discrete Fourier and Fast Fourier Transforms – Discrete Convolution – Periodic sequence and circular convolution – Discrete Fourier Transform – decimation–in-time algorithm – Decimation-in-frequency algorithm – Computation of inverse DFT. (10 + 7)

Z-TRANSFORM: Z - transform of standard functions, inverse Z-transform – properties of Z – transform – Difference equations – Modeling and Solution of difference equations. (8 + 5)

Total L : 45 + T: 30 = 75

TEXT BOOKS:

1. Ram P. Kanwal, 'Linear Integral Equations: Theory and Technique', Birkhäuser, 2013.
2. I.M. Gelfand and S. V. Fomin, 'Calculus of Variations', Dover, 2000.
3. EwinKreyszig, 'Advanced Engineering Mathematics', John Wiley, 2015.

REFERENCES:

1. Ray Wylie C, Louis C Barret, 'Advanced Engineering Mathematics', McGraw Hill, 2003.
2. Michael D. Greenberg, 'Advanced Engineering Mathematics', Pearson Education, 2009.
3. Roland E. Thomas and Albert J. Rosa, 'The Design and Analysis of Linear Circuits', John Wiley, 2011.

20SA65 CLASSICAL MECHANICS

3 2 0 4

Prerequisites::
20SA12 - Real Analysis,
20SA13 - Differential Equations.

THE MECHANICAL SYSTEMS: Introductions, basic properties Generalized coordinates- Constraints - Virtual work - Energy and momentum. (9 + 6)

LAGRANGE'S EQUATIONS: Introduction to Lagrange' s equations, Derivation of Lagrange's equations - Examples - Integrals of the motion. (10 + 7)

HAMILTON'S EQUATIONS: Introduction, Hamilton's principles, Hamilton's equations – Other variational principles. (10 + 7)

HAMILTON – JACOBI THEORY: Hamilton's principal function - The Hamilton – Jacobi equation - Separability. (8 + 5)

CANONICAL TRANSORMATIONS: Differential forms and generating functions - Special transformations - Lagrange and Poisson brackets (8 +5)

Total L : 45 + T: 30 = 75

TEXT BOOKS:

1. Donald T. Greenwood, Classical Dynamics, Dover Publication,1997.
2. Herbert Goldstein, Charles Poole, John Safko, Classical Mechanics, Pearson Education, 2002.

REFERENCES:

1. David Morin, Introduction to Classical Mechanics with problems and solutions, Cambridge University press, 2008.
2. R. Douglas Gregory, Classical Mechanics, Cambridge University press, 2006.

20SA66 COMPUTAIONAL FINANCE

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics.

INTRODUCTION: Computational finance - Cash Flow Streams - Investments and the Market – Forwards, Futures, and Options –No arbitrage and the Law of One Price–Forwards–Futures–Option type, style, and payoff–Put-Call Parity for European options–Put-Call Parity bounds for American options. (5)

MATHEMATICAL PRELIMINARIES : Univariate distributions - quantiles of a distribution, Value-at-Risk – Bivariate distributions - Covariance, correlation, autocorrelation, linear combinations of random variables - Time series analysis: Covariance stationarity, autocorrelations, MA(1) and AR(1) models – Descriptive statistics - Stochastic calculus Martingales and Brownian motion. (10)

PORTFOLIO THEORY - Introduction - Review of constrained optimization methods, Markowitz algorithm, Markowitz Algorithm using the solver and matrix algebra – Markowitz algorithm with no short sales constraints-Portfolio risk budgeting– Statistical analysis of efficient portfolios. (10)

BASIC OPTIONS THEORY – Definitions – Pay off diagrams – Single period binomial options theory – Multi period binomial options theory – Real options-Simulation methods for options pricing. (10)

THE CAPITAL ASSET PRICING (CAP) AND RISK BUDGETING : Mean variance portfolio theory – Asset returns Variance as a risk measure - The one and two fund theorems – The capital market line – CAP as a pricing formula Systematic and unsystematic risk – Euler's theorem – Asset contributions to volatility –Beta as a measure of portfolio risk-limitations. (10)

Total L : 45 + T: 30 = 75

Tutorial Practices:
1. Obtaining financial data, computing returns, plotting and basic analysis
2. Working with time series data

3. Linear time series modeling andforecasting
4. Modeling volatility: Volatility forecasting for risk management
5. Portfolio optimization: Mean-variance model
6. Tangency portfolio and Capital MarketLine
7. Asset Pricing model: Capital Asset Pricing Model, Beta estimation
8. Estimating the Term Structureof Interest Rates
9. Derivatives Pricing: The Black-Scholes model, The Cox-Ross-Rubinstein model.

TEXT BOOKS:

1. David Ruppert, 'Statistics and Data Analysis for Financial Engineering', Springer, 2013.
2 . MarekCapinski and Tomasz Zastawniak, 'Mathematics for Finance', Springer, 2011.

REFERENCES:

1. John C. Hull, 'Options, Futures and Other Derivatives', Pearson Education, 2016.
2. Steven E Shreve, 'Stochastic Calculus for Finance – I' , Springer, 2005.
3. Sheldon M. Ross, 'An Elementary Introduction to Mathematical Finance', Cambridge University Press, 2011.

20SA67 DATA MINING

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics.

INTRODUCTION: Data mining, kinds of data, kinds of patterns, major issues in data mining; Data objects and attribute types, measuring data similarity and dissimilarity. (6)

DATA PREPROCESSING: Data pre-processing, data cleaning, data integration, data reduction' (5)

MINING FREQUENT PATTERNS, ASSOCIATIONS AND CORRELATIONS: Basic concepts, frequent item set mining methods, apriori algorithm, FP tree, pattern evaluation methods. . (9)

CLASSIFICATION: Basic concepts, decision tree induction, Bayes classification methods, model evaluation and selection, metrics for evaluating classifier performance, Holdout methods and Random sub sampling, Cross-validation and ROC Curves, Techniques to improve classification accuracy, Bagging, Boosting and AdaBoost. (9)

CLUSTER ANALYSIS: Cluster analysis, partitioning methods, K-means, K-medoids, hierarchical methods, agglomerative versus divisive hierarchical clustering, density-based methods. (9)

TRENDS IN DATA MINING: Mining distributed heterogeneous and legacy databases, Multimedia data mining, Data mining and theWorld Wide Web, Security and Privacy issues for data mining,
Case Studies:
Text mining: extracting attributes (keywords), Bayesian approach to classifying text
Web mining: classifying web pages, extracting knowledge from the web
Graph Mining: Sub-structure matching (7)

Total L : 45 + T: 30 = 75

Tutorial Practices:
1. Implementation of data mining techniques using WEKA.
2. Implementation of Association rule mining using Apriori algorithm and FP Growth algorithm
3. Classification rules using Decision Tree classifier, Ensemble of Classifiers.
4. Implementation of clustering algorithms
5. Case studies using R programming.

TEXT BOOKS:

1. Jiawei Han, MichelineKamber and Jian Pei, 'Data Mining – Concepts and Techniques', Reed Elsevier, 2012.
2. Tan, Steinbach and Kumar, 'Introduction to Data Mining', Pearson Education, 2013.
3. Trevor Hastie, Robert Tibshirani and Jerome Freidman, 'The Elements of Statistical Learning: Data Mining, Inference, and Prediction', Springer Series in Statistics, 2009.

REFERENCES:

1. Ian Witten, Frank Eibe and Mark A Hall, 'Data Mining: Practical Machine Learning Tools and Techniques"' Elsevier, 2011.
2. Charu C. Aggarwal, Haixun Wang, 'Managing and Mining Graph Data', Springer, 2010.
3 .Michael W. Berry, Jacob Kogan, 'Text Mining: Applications and Theory', Wiley, 2010.

20SA68 DESIGN AND ANALYSIS OF ALGORITHMS

3 2 0 4

Prerequisites:
20SA15- Discrete Mathematics,
20SA24 - Data Structures.

INTRODUCTION: Algorithm – analysis of algorithms – best case and worst case complexities. Asymptotic notations-Master's Theorem. (3)

SORTING ALGORITHMS: Insertion sort- Selection sort- Heap sort-Radix sort-time complexity analysis. (3)

DIVIDE AND CONQUER: Method – examples – Merge sort, Quick sort, Strassen's matrix multiplication, Closest Pair. (6)

GREEDY METHOD: Optimization problems – method – examples – Minimum cost spanning tree (Kruskal'sand prim'salgorithms), Topological sorting, Huffman coding, Fractional knapsack. (8)

DYNAMIC PROGRAMMING: Method – examples –0/1 Knapsack-All pairs shortest path problem -Traveling salesman problem. (6)

NETWORK FLOW: Flows and Cuts-Max flow mincut theorem-Ford Fulkerson's Algorithm (5)

NP-HARD, NP-COMPLETE CLASSES: Basic concepts – Non deterministic algorithms – satisfiability problem – NP-hard and NP-complete Problems – Cooks theorem (statement only)- Reduction- Vertex cover. (6)

BACK TRACKING: Method – Examples – Eight queen's problem, Hamiltonian Cycles. (4)

BRANCH &BOUND: Method – Example – 0/1 knapsack-Traveling salesman problem (4)

Total L : 45 + T: 30 = 75

Tutorial Practices:
. Implementation of the following problems:
1. Divide and Conquer versions of Merge sort, Quick sort, binary search and closest pair
2. Greedy method implementation of Topological sort, Minimum cost spanning tree.
3. Dynamic Programming implementation of Traveling Salesperson problem.
4. Eight queen's problem backtracking algorithm.
5. Knapsack using branch and bound algorithm

TEXT BOOKS:
1. Thomas H. Cormen, Charles E. Leiserson, and Ronald LRivest, 'Introduction to Algorithms', MIT Press, 2015.
2. Jon Kleinberg and Eve Tardos, 'Algorithm Design', Pearson Education, 2013.

REFERENCES:
1. AnanyLevitin, 'Introduction to Design and Analysis of Algorithms', Pearson Education, 2012.
2. Michael T. Goodrich and Roberto Tamassia, 'Algorithm Design, Foundations, Analysis, and Internet Examples', Wiley, 2014.

20SA69 DIGITAL IMAGE PROCESSING AND COMPUTER VISION

3 2 0 4

Prerequisites:
20SA24 - Data Structures.

DIGITAL IMAGE FUNDAMENTALS: Image Sampling and Quantization, Digital Image Representation, Image Types, Pixel neighborhood. (3)

IMAGE ENHANCEMENT: Noise models, Point Operations, Histogram Processing, Spatial Operations, Multispectral Image Enhancement, Color Image Enhancement. Image Transforms - Fourier Transform, Discrete Cosine Transform, \Wavelets. (6)

EDGE DETECTION: The Purpose of Edge Detection, Traditional Approaches and Theory, Edge Models, Comparison of Two Optimal Edge Detectors, Color Edges. (5)

DIGITAL MORPHOLOGY: Connectedness, Binary Operations, Dilation and Erosion, Opening and Closing, Grey-Level Morphology, Color Morphology. (4)

GREY-LEVEL SEGMENTATION: Basics of Grey-Level Segmentation, The Use of Regional Thresholds, Moving Averages, Cluster-Based Thresholds, Multiple Thresholds, Region-based segmentation, Watershed Transform.

(9)

IMAGE RESTORATION: Image Degradations, The Frequency Domain, The Inverse Filter, The Wiener Filter, Structured Noise, Motion Blur, The Homomorphic Filter, Least Square Filters, Generalized Inverse & Iterative Methods, Recursive filtering, Bayesian Methods. (9)

IMAGE ANALYSIS AND CPMPUTER VISION: Feature Extraction - color, texture and shape features, Dimensionality Reduction, Clustering and Classification. (9)

Total L : 45 + T: 30 = 75

Tutorial Practices:
1. Basic image processing techniques like sampling and quantization
2. Implementation of Image segmentation and edge detection.
3. Implementation of Histogram equalization.
4. Implementation of 2-D DFT and DCT.
5. Implementation of feature extraction.
6. Implementation of image filtering methods in spatial and frequency domain.
7. Image restoration.
8. Implementation of image classification and clustering.
9. Developing simple image analysis applications.

TEXT BOOKS:
1. Rafael C Gonzalez and Richard E Woods, 'Digital Image Processing", Prentice Hall, 2011.
2. Kenneth R Castleman, "Digital Image Processing", Pearson Education, 2007.

REFERENCES:
1. Maria Petrou , Costas Petrou, "Image Processing: The Fundamentals", John Wiley& Sons, 2010.
2. Anil K Jain. "Fundamentals of Digital Image Processing", Prentice Hall, 2001.

20SA70 EPIDEMIC MODELS

3 2 0 4

Prerequisites:
20SA13 – Differential Equations,
20SA14 - Probability, Stochastic Processes and Statistics

BASICS OF EPIDEMICS: The epidemic in a closed population – Initial growth-the final size. Heterogeneity: Differences in infectivity, differences in infectivity and susceptibility. (8 + 5)

STRUCTURED POPULATIONS: The concept of state-i-states, p-states, recapitulation and problem formulation (8 + 5)

THE BASIC REPRODUCTION RATIO: The definition of R_0, general h-state, on conditions that simplify the computation of R_0, sub models for the kernel, extended example, pair formulation models. Partially vaccinated populations, the intrinsic growth rate r, some generalities, separable mixing. (15 + 11)

MACROPARASITES: Introduction, counting parasite load, the calculation of R_0 for life cycles, seasonality and R_0, a pathological mode. (8 +5)

CONTACT: Introduction, Contact duration, consistency conditions, effects of subdivision, network models. (6 + 4)

Total L : 45 + T: 30 = 75

TEXT BOOKS:
1. O.Diekmann, J.A.P. Heesterbeek, "Mathematical Epidemiology of Infectious Diseases: Model building, Analysis and Interpretation", John Wiley, 2000.
2. Roy M. Anderson and Robert M. May, "Infectious diseases of humans; dynamic and control" Oxford university Press, 1992.

REFERENCES:
1. Diekmann O., Heesterbeek, J.A.P. and Britton, T. Mathematical tools for understanding infectious disease dynamics. Princeton, Univ. Press, 2012.

20SA71 GAME THEORY

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics.

INTRODUCTION: Basic concepts -Theory of rational choice – Interacting decision makers (2)

STRATEGIC GAMES AND NASHEQUILIBRIUM: Strategic games: Examples –Nash equilibrium: concept and examples -Best response – Dominated actions –Symmetric games and symmetric equilibria- Illustrations: Cournot's and Bertrand's models of duopoly,Electoral competition, War of Attrition , Auctions, Accident Laws. (8 + 6)

MIXED STRATEGY NASHEQUILIBRIUM::Introduction, Strategic games with randomization- Mixed strategy Nash equilibrium: concept and examples - Dominated Actions -Formation of Players' beliefs - Illustrations: Expert diagnosis, Reporting a crime. (6 + 4)

EXTENSIVE GAMES WITH PERFECT INFORMATION: Strategies and outcomes – Nash equilibrium – Sub game perfect equilibrium –Backward induction - Illustrations: Stackelberg's model of duopoly, Buying votes, Ultimatum game. (6 + 4)

GAMES WITH IMPERFECT INFORMATION: Bayesian games – Examples – Strategic information – Transmission – Agenda Control with imperfect Information – Signaling games - Education as a signal of ability. (6 + 4)

REPEATED GAMES: Nash equilibrium in repeated games, finitely and infinitely repeated Prisoner's Dilemma - – Sub game – Perfect equilibria and the one – deviation – Property – General results – Finitely replaced games – Variation on a theme: Imperfect observability. (6 +5)

BARGAINING: Rubinstein Bargaining Model with Alternating Offers -Nash Bargaining Solution- Relation of Axiomatic and Strategic Model- Illustration: Trade in market. (5 +3)

AUCTION AND MECHANISM DESIGN: introduction- The Vickery auction- Sponsored Search auction- Social Choice theory- VCG mechanism. (6 + 4)

Total L : 45 + T: 30 = 75

TEXT BOOKS:

1. Martin J. Osborne, 'An Introduction to game theory', Oxford University Press, 2004.
2. Nisan N., Roughgarden T.,Tardos E., Vazirani V., 'Algorithmic Game Theory', Cambridge University Press, 2007.

REFERENCES:

1. Thomas L.C, 'Games, Theory and Applications', Dover Publications, 2011.
2. Ken Binmore, 'Playing for Real: A Text on Game Theory', Oxford University Press, 2007.
3. David Easley, Jon Kleinberg, 'Networks, Crowds, and Markets: Reasoning About a Highly Connected World', Cambridge University Press, 2010.
4. Matthew O. Jackson, 'Social and Economic Networks', Princeton University Press, 2008.

20SA72 GEOMETRY OF LOCALLY FINITE SPACES

3 2 0 4

Prerequisites:
20SA11 - Contemporary Algebra,
20SA12 - Real Analysis,
20SA21 – Topology and Functional Analysis.

AXIOMATIC APPROACH TO DIGITAL TOPOLOGY: Axioms of Digital Topology, Relation between the suggested and classical Axioms, Deducing the properties of ALF spaces from the axioms**.** (8 + 5)

ABSTACT CELL COMPLEXES: Topology of complexes, Cartesian complexes and combinatorial coordinates, AC complexes compared with other Locally Finite Spaces. (10 + 7)

COMBINOTORIAL HOMEOMORPHISM: Definition of combinatorial homeomorphism, balls and spheres, generalized boundary and boundary of space, orientation of AC complexes, combinatorial manifolds, block complexes, consistency of the (m,n)-adjacencies. (10 + 7)

MAPPINGS AMONG LOCALLY FINITE SPACES: Connected –Preserving Mappings **(CPM),** the combinatorial homeomorphism, properties of manifolds and block complexes. (8 + 5)

HOMOLOGY: Homology of groups, matrix reduction, relative homology, exact sequences, co-homology. (9 + 6)

Total L : 45 + T: 30 = 75

TEXT BOOKS:

1.Vladimir A. Kovalevsky, 'Geometry of Locally Finite Spaces: Computer Agreeable Topology and Algorithms for Computer Imaginary', House Dr. Baerbel Kovalevski,2008.
2.Herbert Edlesbrunner and John Harer, Computational Topology An Introduction', AMS,2010.

REFERERNCES:

1. James R. Munkres, 'Topology- A First Course', Pearson, 2018.
2. Allen Hatcher, 'Algebraic Topology', Cambridge University Press, 2002.

20SA73 INFORMATION RETRIEVAL AND WEBSEARCH

3 2 0 4

Prerequisites:
20SA11 – Contemporary Algebra,
20SA14 – Probability, Stochastic Processes and Statistics,
20SA24 - Data structures.

INTRODUCTION: Overview of IR Systems - Historical Perspectives - Goals of IR - The impact of the web on IR - The role of artificial intelligence (AI) in IR. (3)

TEXT REPRESENTATION: Statistical Characteristics of Text: Zipf's law; Porter stemmer; morphology; index term selection; using thesauri. **Basic Tokenizing, Indexing:** Simple tokenizing, stop-word removal, and stemming; inverted indices; Data Structure and File Organization for IR - efficient processing with sparse vectors. (6)

RETRIEVAL MODELS: Similarity Measures and Ranking - Boolean Matching – Extended Boolean models – Ranked retrieval - Vector Space Models -, text-similarity metrics - TF-IDF (term frequency/inverse document frequency) weighting - cosine similarity, Probabilistic Models, Evaluations on benchmark text collections. (8)

QUERY PROCESSING: **Query Operations and Languages**- Query expansion; Experimental Evaluation of IR: Performance metrics: recall, precision, and F-measure. (5)

TEXT CATEGORIZATION AND CLUSTERING: Categorization: Rocchio; Naive Bayes, kNN; Clustering: Agglomerative clustering; k-means; Expectation Maximization (EM); Dimension Reduction: LSI, PCA. (6)

INFORMATION FILTERING TECHNIQUES: introduction to Information Filtering, Relevance Feedback - Applications of Information Filtering: **RECOMMENDER SYSTEMS**: Collaborative filtering and Content-Based recommendation of documents and products. (6)

WEB SEARCH: IR Systems and the WWW - Search Engines: Spidering, Meta Crawlers; Link analysis: Hubs and Authorities, Google PageRank, Duplicate Detection, (5)

INFORMATION EXTRACTION AND INTEGRATION: Extracting data from text; Basic Techniques: Named Entity Recognition, Co-reference Resolution, Relation Extraction, Event Extraction; Extracting and Integrating specialized information on the Web, Web Mining and Its Applications. (6)

Total L : 45 + T: 30 = 75

Tutorial Practices:

1. Different retrieval models - Boolean, Vector space and Probability based retrieval.
2. Query refinement techniques
3. Evaluation of the retrieval algorithms.
4. Dimension Reduction techniques
5. Classification and Clustering techniques
6. Recommender systems- Collaborative and Content Based Filtering
7. Information Extraction techniques
8. Web based retrieval - Link based retrieval, combining content and link information.

TEXT BOOKS:

1. Christopher D. Manning, PrabhakarRaghavan and HinrichSchütze, 'Introduction to Information Retrieval', Cambridge University Press, 2012.
2. B.Croft, D. Metzler, T. Strohman, 'Search Engines: Information Retrieval in Practice', Pearson Education, 2015.

REFERENCES:

1. Stefan Büttcher, Charles L. A. Clarke, Gordon V. Cormack, 'Information Retrieval – Implementing and Evaluating Search Engines', The MIT Press, 2016
2. Ricardo Baeza-Yates and BerthierRibeiro-Neto, 'Modern Information Retrieval', Pearson Education, 2010.
3. Francesco Ricci, LiorRokach, BrachaShapira, Paul B. Kantor, 'Recommender Systems – Handbook', Springer, 2015.

20SA74 MATHEMATICAL MODELING

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics,
20SA15 - Discrete Mathematics.

INTRODUCTION TO MODELING: Modeling process, Overview of different kinds of model. (2)

EMPIRICAL MODELING WITH DATA FITTING: Error function, least squares method; fitting data with polynomials and Splines. (4)

CAUSAL MODELING AND FORECASTING: Introduction, Modeling the causal time series, forecasting by regression analysis,predictions by regression. Planning, development and maintenance of linear models, trend analysis,modeling seasonality and trend,trend removal and cyclical analysis, decomposition analysis. Modeling financial time series. Econometrics and time series models.Non seasonal models: ARIMA process for univariate and multivariate. (10)

PORTFOLIO MODELING AND ANALYSIS: Portfolios, returns and risk, risk-reward analysis, asset pricing models, mean variance portfolio optimization, Markowitz model and efficient frontier calculation algorithm, Capital Asset Pricing Models (CAPM). (12)

DISCRETE-TIME FINANCE: Pricing by arbitrage, risk-neutral probability measures, valuation of contingent claims, and fundamental theorem of asset pricing, Cox-Ross-Rubinstein (CRR) model, pricing and hedging of European and American derivatives as well as fixed-income derivatives in CRR model, general results related to prices of derivatives (5)

MODELING WITH BIOINFORMATICS: Introduction, Biological data- types, mode of collection, documentation and submission. Sequence alignment- Definition, significance, dot matrix method, dynamic programming- Global and local alignment tools, scoring matrices and gap penalties. Multiple sequence alignment: Iterative methods. (12)

Total L : 45 + T :30 = 75

Tutorial Practices:
1 Least square method for fitting data
2. Modeling financial time series
3. ARIMA process
4. Markowitz model for portfolio modeling
5. Capital asset pricing models
6. CRR model
7. Sequence alignment by using dynamic programming technique
8. Multiple sequence alignment.

TEXT BOOKS:

1. Giordano F R, Weir M D, and Fox W P, 'A First Course in Mathematical Modeling'. Brooks/Cole, Belmont, 2014.
2. Capinski M. and ZastawniakT,'Mathematics for Finance: An Introduction to Financial Engineering', Springer, 2011.
3. Mount. DW, 'Bioinformatics Sequence and Genome Analysis', Cold Spring Harbor Laboratory, Press, 2006.

REFERENCES:

1. Hamdy A. Taha, 'Operation Research- An Introduction', Pearson Education, 2012.
2. Christoffersen. P, 'Elements of Financial Risk Management', Academic Press,2012.
3. G.Polya, ' How to Solve it: : New Aspect of Mathematical Method', Princeton University Press, 2018.

20SA75 MOBILE APPLICATION AND DEVELOPMENT

3 2 0 4

Prerequisites:
20SA23 - Object oriented programming.

MOBILE AND WIRELESS DEVICES: Introduction - Evolution of mobile communication generations- Challenges in mobile computing – Vertical and horizontal mobile applications. (8)

CELLULAR CONCEPT: Wireless transmission - Frequencies for radio transmission - Regulations - Signals , Antennas, Signal propagation ,Path loss of radio signals , Additional signal propagation effects - Multi-path propagation – Cell Concept - Factors determining cell size and shape. (10)

MOBILE APPLICATIONS ARCHITECTURE: Smart Client – Smart Client Architecture – Messaging Architecture The Model-View-Controller Model - Delegate Pattern- Building Smart Client Applications-Design, Development, implementation, testing and deployment phase- MVVM mobile architecture design. (10)

MOBILE APPLICATION DEVELOPMENT: Introduction to Android Platform – Android architecture overview - Application life cycle - UI design for Android - UI fragments - Different types of layouts – Widgets – List view – View pager – Dialogs, (10)

DATABASE: Files and database – SQLite on Android – Loading asynchronous data - Map API. (7)

Total L : 45 + T: 30 = 75

Tutorial Practices:
1. Android SDK installation and study
2. Defining Layouts
3. Single Activity Application, Application with multiple activities, using intents to Launch Activities
4. Application using GUI Widgets
5. Application with Notifications
6. Creating and Saving Shared Preferences and Retrieving Shared Preferences
7. Usage of SQLite Databases for storage
8. Working with Retrofit library in Android Applications
9. Android Automated Testing Frameworks
10. Case Study: Dagger Framework for Android .

TEXT BOOKS:
1. Jochen Schiller, 'Mobile Communications', Pearson Education, 2012.
2. Bill Philips, Kristin Marsicano and Chris Stewart, 'Android Programming: The big Nerd Ranch guide', O'Reilly, 2017.
3. MartynMallick, 'Mobile and Wireless Design Essentials', Wiley, 2003.

REFERENCES::
1. Ronan Schwarz, Phil Dutson, James Steele and Nelson To, 'The Android Developer's Cookbook -Building Applications with theAndroid SDK', Addison Wesley, 2013**.**

20SA76 OPERATING SYSTEMS

3 2 0 4

INTRODUCTION: Abstract view of an operating system - Operating Systems Objectives and Functions – Evolution of Operating Systems - Dual-mode operation - System calls- Structure of Operating System. (3)

PROCESS DESCRIPTION AND CONTROL: Process concepts - Process Creation – Process Termination – Process states - Process Description – Process Control (3)

PROCESS AND THREADS: Relationship between process and threads – Thread States – Thread Synchronization Types of Thread – Multithreading model. (4)

PROCESS SCHEDULING: Scheduling basics - CPU-I/O interleaving- (non-)preemption - context switching- Types of **]**Scheduling – Scheduling Criteria - Scheduling Algorithms – Algorithm evaluation – Real-time scheduling**.** (5)

PROCESS SYNCHRONIZATION: Concurrent Process – Principles of Concurrency – Race Condition - Mutual Exclusion – Critical section problems – Software support – Hardware Support – Operating System Support: Semaphore, Monitor – Classical problems of synchronization – Synchronization examples. (4)

DEADLOCK:Principles- Characterization – Methods for handling deadlock - Deadlock prevention, Avoidance, Detection, and recovery. (4)

MEMORY MANAGEMENT: Memory hierarchy –Memory Management requirements - Memory partitioning: Fixed partitioning, Dynamic partitioning, Buddy systems – Simple paging – Page table structures – Simple Segmentation – segmentation and paging. (6)

VIRTUAL MEMORY MANAGEMENT: Need for Virtual Memory management – Demand Paging –Copy on write - Page Fault handling - Page replacement - Frame allocation- Thrashing - working set model. (5)

I/O MANAGEMENT AND DISK SCHEDULING: Organization of I/O function – Evolution of I/O function – Types of I/O devices – Logical Structure of I/O functions – I/O Buffering – Disk I/O – Disk Scheduling algorithms – RAID - Disk Cache. (4)

FILE SYSTEM MANAGEMENT: Files – Access methods - File system architecture – Functions of file management –Directory and disk structure -Mounting - File sharing –File system implementation – Directory implementation - File Allocation – Free space management. (4)

VIRTUALIZATION: Requirements for Virtualization - Type 1, Type 2 Hypervisors – Paravirtualization- Memory Virtualization - I/O Virtualization - Virtual machines on Multicore CPUs–Virtualization in Multiprocessor environment. (3)

Total L : 45 + T: 30 = 75

Tutorial Practices:

1. Practicing UNIX Commands
2. Writing SHELL Scripts
3. Writing programs using UNIX System Calls
4. Process Creation and Execution
5. Thread Creation and Execution
6. Process / Thread Synchronization using semaphore
7. Developing Application using Inter Process communication (using sharedmemory, pipes or message queues)
8. Implementation of Memory Management Schemes
9. Implementation of file allocation technique (Linked, Indexed, Contiguous).

TEXT BOOKS:

1. Silberschatz A, Galvin, PB. and Gagne, G. 'Operating System Concepts', John Wiley & Sons, Inc.,2018.
2. William Stallings, 'Operating Systems: Internals and Design Principles', Pearson Education, 2017.
3. Andrew S Tanenbaum, 'Modern Operating System', Prentice Hall, 2018.

REFERENCES:

1. Elmasri, E., Carrick A.G. and Levine, D. 'Operating Systems: A Spiral Approach', McGraw Hill, 2014.
2. McHoes, AM and Flynn, I.M. 'Understanding Operating Systems', Cengage Learning, 2016.
3.Dhamdhere D M, 'Operating Systems: A Concept-based Approach', McGraw-Hill, 2015.

20SA77 PREDICTIVE ANALYTICS

3 2 0 4

Prerequisites:
20SA14 - Probability, Stochastic Processes and Statistics

DATA WRANGLING : DataIngest, Data Cleaning - Exploratory data analysis - Univariate data – Bivariate data, Multivariate data. (5 + 3)

LINEAR REGRESSION: Coefficient of determination, Significance test, Residual analysis, Confidence and Prediction intervals. (5 + 3)

MULTIPLE LINEAR REGRESSION: Coefficient of determination, Interpretation of regression coefficients, Categorical variables, heteroscedasticity, Multi-co linearity outliers, Auto regression and Transformation of variables, Regression, Model Building (10 + 7)

LOGISTIC AND MULTINOMIAL REGRESSION: Logistic function, Estimation of probability using Logistic regression, Variance, Wald Test, HosmerLemshow Test, Classification Table, Gini Co-efficient. (5 + 3)

DECISION TREES: introduction, CHI-Square Automatic Interaction Detectors (CHAID), Classification and Regression Tree(CART), Analysis of Unstructured data. (5 + 3)

FORECASTING: Moving average, Exponential Smoothing, Casual Models. (5 + 3)

TIME SERIES ANALYSIS: Moving Average Models, ARMA, ARIMA models , Multivariate Models. (5 + 3)

CASE STUDIES : Application of predictive analytics in retail, direct marketing, health care, financial services, insurance, supplychain, Social mediaanalytics– Customer Analytics - Risk Analytics - Analytics for Retail and Ecommerce, etc- Working with datafrom different sources: spreadsheets, databases, and the cloud -Model Development- Model Validation. (5 + 5)

Total L : 45 + T: 30 = 75

TEXT BOOKS:

1. Daniel T. Larose, Chantal D. Larose, 'Data Mining and Predictive Analytics', Wiley,2015
2. Douglas C. Montgomery, Cheryl L. Jennings, Murat Kulachi, 'Introduction to Time Series Analysis and Forecasting',Wiley, 2015.
3. Max Kuhn, Kjell Johnson, 'Applied Predictive Modeling', Springer, 2014.

REFERENCES:

1. Richard A. Johnson, Irwin Miller and John Freund, 'Probability and Statistics for Engineers', Pearson Education, 2014.
2. Ronald E. Walpole, Raymond H. Meyers, Sharon L. Meyers, 'Probability and Statistics for Engineers and Scientists', Pearson Education, 2014.
3. Thomas W.Miller, 'Modeling Techniques in Predictive Analytics with Python and R A guide to Data Science', Pearson Education, 2014.

20SA78 STATISTICAL LEARNING

3 2 0 4

Prerequisites:
20SA12 – Real Analysis,
20SA14 – Probability, Stochastic Processes and Statistics,
20SA21 - Topology and Functional Analysis

THEORETICAL FOUNDATIONS : Review of Statistical Inference, Review of Probability, Testing of Hypothesis – Introduction to FunctionSpaces – Vector Spaces - Metric Spaces – Cauchy Sequence – Complete Metric Space – Normed Space, Inner Product Space – BanachSpace - Hilbert Space – Sobolev– Examples - Mercer Kernels - Reproducing Kernel Hilbert Space (RKHS), Concentration of Measure Measures of Complexity - Rademacher Complexity. (10)

LINEAR REGRESSION: Simple, Multiple, Other Considerations in the Regression Model – Resampling Methods Cross-Validation, Bootstrap– Linear Model Selection & Regularisation – Subset Selection , Shrinkage Methods – Ridge, Lasso, Dimension Reduction Methods, (8)

NON-LINEAR REGRESSION : Polynomial Estimators, Step Functions, Basis Functions, Regression Spline Smoothing Splines, Local Regression, Generalised Additive Models. (4)

LINEAR CLASSIFICATION: Review of Classification Models, Logistic Regression, Linear Discriminant Analysis, Quadratic Discriminant Analysis, Comparison of Classification Methods. (6)

TREE BASED METHODS: Regression Trees, Classification Trees, Bagging, Random Forests, Boosting. (9)

SUPPORT VECTOR MACHINES: Maximal Margin Classifier – Support Vector Classifiers - Support Vector Machines – Non-linear DecisionBoundaries – SVMs with more than 2 classes. (4)

UNSUPERVISED LEARNING: Principal Components Analysis – Clustering Methods – K-Means Clustering, Hierarchical Clustering (4)

Total L : 45 + T: 30 = 75

Tutorial Practices:
Solve the following problems using R
1. Simple Regression, Multiple Regression, Ridge Regression and Lasso Regression.
2. Non-linear Regression, Splines and Additive Models
3. Linear Classification,
4. Tree based methods
5. Support Vector machines
6. Clustering Methods

TEXT BOOKS:
1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, “An introduction to Statistical learning”, Springer, 2013.
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, “Elements of Statistical Learning: Data Mining, Inference and Prediction”, Springer,2013.

REFERENCES:
1. Vladimir N Vapnik, “Statistical learning theory”, Wiley, 1998.
2. Robert Schapire, Yoav Freund, “Boosting : Foundations and Algorithms”, The MIT Press, 2012.

20SA79 STOCHASTIC DIFFERENTIAL EQUATIONS

3 2 0 4

Prerequisites:
20SA13- Differential Equations,
20SA15- Probability, Stochastic Processes and Statistics.

MATHEMATICAL PRELIMINARIES: Probability spaces - Random variables - Stochastic processes – Brownian motion. (7 +4)

ITO STOCHASTIC CALCULUS: Ito Integrals - Construction of its integrals - Properties (9 +6)

THE ITO FORMULA AND THE MARTINGALE REPRESENTATION THEOREM: The one-dimensional Ito formula - The multi-dimensional Ito formula – The Martingale representation theorem (9 + 6)

STOCHASTIC DIFFERENTIAL EQUATIONS: Construction of stochastic differential equations - an existence and uniqueness result- weak and strong solutions. (10 + 7)

METHOD OF SOLVING STOCHASTIC DIFFERENTIAL EQUATIONS: Linear stochastic differential equations - Reducible stochastic differential equations - Some explicitly solvable equations. (10 + 7)

Total L : 45 + T: 30 = 75

TEXT BOOKS:
1. Peter E Kloeden and EckhardPlaten,'Numerical Solution of Stochastic Differential Equations', Springer, 2018.
2. BerntOksendal , 'Stochastic Differential Equations - An Introduction with Applications', Springer, 2016.

REFERENCES:
1. Sasha Cyganowski, Peter Kloeden and Jerry Ombach, 'From Elementary Probability to Stochastic Differential Equations with Maple', Springer, 2002.

20SA80 TOPOLOGICAL DATA ANALYSIS

3 2 0 4

Prerequisites:
20SA11 - Contemporary Algebra,
20SA12 - Real Analysis,
20SA21 - Topology and Functional Analysis.

COMPLEXES: Topological spaces, Continuity, Connectedness, Surfaces, Homeomorphisms, Homotopy, Isotopy, Simplices, Simplicial Complex, Euler characteristics. (6+4)

HOMOLOGY : Simplical Homology, Chain complexes, Cycles and boundaries, Homology groups and Betti numbers, The homology of a ball, Reduced homology, Induced maps, Matrix reduction: Euler-Poincaré formula, Boundary matrices, Smith normal forms, Reduction algorithm; Relative homology groups; Excision, Maps between vector spaces, Exact sequences: Chain complexes and chain maps, The snake or zig-zag, Connecting homomorphism, Mayer-Vietoris sequence, cohomology (12+8)

MORSE THEORY: Generic smooth functions, Morse functions, Morse lemma, Gradient vector field on a manifold, Attaching cells, Transversality, Integral lines, Stable and unstable manifolds, Morse-Smale functions, Morse-Smale complexes, Morse inequalities, Floer homology, Relation between Morse theory and Homology. (10+7)

PERSISTENT HOMOLOGY: The elder rule, Filtrations, Persistence, diagrams, Matrix reduction, Pairing lemma, Sparse matrix representation, Extended persistence, Spectral sequence, Stability, Bottleneck distance, Tame functions, Wasserstein distance, Length and total curvature of a curve using stability, Bipartite graph matching for computing bottleneck distance. (10+7)

DATA-STRUCTURES: Piecewise-linear functions, Scalar data analysis: Contour tree and Reeb graph, Vector data analysis. (7+4)

TEXT BOOKS:
1 .Herbert Edlesbrunner and John Harer, 'Computational Topology – An Introduction', AMS, 2010.
2. James R. Munkres, 'Topology- A First Course', Pearson, 2018.
3. JamesR. Munkres." Elements of Algebraic Topology'. CRC Press, 2018.

REFERENCES:
1. John M.Lee, 'Introduction to Topological Manifold, Springer, 2011.
2. G unter Rote and GertVegter.'Computational Topology - An introduction (Effective Computational Geometry for Curves and Surfaces (Chapter 7)), Springer, 2006.